EO-1 ICD-025
Baseline
May 7, 1998

New Millennium Project
Earth Orbiter-1 (EO-1) Mission

EO-1 Spacecraft
to Global Positioning System (GPS)
Navigation Sensor
Interface Control Document

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

EO-1 ICD-025
Baseline
May 7, 1998

New Millennium Project
Earth Orbiter-1 (EO-1) Mission

EO-1 Spacecraft
to Global Positioning System (GPS)
Navigation Sensor
Interface Control Document

Goddard Space Flight Center
Greenbelt, Maryland

Change Information Page

List of Effective Pages	
Page Number	**Issue**
Title page	Baseline
iii through viii	Baseline
1-1	Baseline
1-2	IRN 001
2-1 through 2-3	Baseline
3-1 through 3-2	IRN 001
3-3 through 3-4	Baseline
3-5 through 3-7	IRN 001
4-1 through 4-3	Baseline
5-1	Baseline
6-1	IRN 001
6-2 through 6-3	Baseline
7-1	IRN 001
7-2	Baseline
8-1	IRN 001
AB-1 through AB-2	Baseline

Revision	Description	Date	Approval
–	Initial Release		5/07/98
IRN 001	EO-1CCR 0014	6/18/98	6/22/98

Contents

Section 1. Introduction

Section 2. Physical Characteristics

Section 3. Electrical Characteristics

Section 4. Mechanical Interface

Section 5. Software Description

Section 6. Operational Requirements

Section 7. Deliverables to the EO-1 Project

Section 8. EO-1 Spacecraft Specifics

Figures

Tables

Abbreviations and Acronyms

Section 1. Introduction

The Goddard Space Flight Center (GSFC) Earth Orbiter 1 (EO-1) spacecraft is being developed as part of the National Aeronautics and Space Administration's (NASA's) New Millennium Program (NMP). A Global Positioning System (GPS) capability has been baselined for the EO-1 mission to provide onboard, real-time output of precise timing and navigation information for use by the Attitude Control System (ACS). The term *GPS* will be used in this document to refer to the entire system that comprises the following subassemblies:

- One Power Conditioning Unit (PCU)
- One Receiver Processor Unit (RPU) with resident flight software
- One four-channel Preamplifier/Splitter Assembly (P/SA)
- Four GPS patch antennas (L1 frequency)
- Wire harnessing and radio frequency (RF) cables connecting all subassemblies

The GPS RPU, manufactured by Space Systems/Loral, is the receiver selected for the EO-1 mission and will be referred to herein by its product name: the Tensor™. The Tensor is a Standard Positioning Service (SPS) receiver that offers 13 real-time output states of precise time information, navigation position and velocity, and attitude angles and rates.

The GPS uses four antennas to achieve maximum coverage for an Earth-pointing vehicle. The GPS is to be turned on after orbital injection and remain on throughout the 1-year design life of the EO-1 spacecraft (and throughout any subsequent extended operations). The primary function of the GPS is to provide the EO-1 spacecraft with precise real-time navigation and timing information. Position and velocity vectors obtained from the GPS are to be used to define the primary spacecraft attitude reference frame, while the digital time obtained from the GPS, in conjunction with the discrete pulse train, may be employed to update the spacecraft oscillator. Secondary functions of the GPS are intended to demonstrate the receiver as a new technology under the NMP. These demonstrations include Autonomous Orbit Control and an Enhanced Formation Flying experiment using GPS data.

1.1 Purpose and Scope

The purpose of this interface control document (ICD) is to ensure successful integration of the GPS onto the EO-1 spacecraft by documenting form, fit, and function interfaces required to achieve installation, checkout, and orbital mission objectives. This ICD delineates the responsibilities of Swales and Litton as the spacecraft integration contractors, and GSFC as the GPS provider, by defining criteria for mechanical, structural, mass property, electrical, thermal, command, telemetry, and power interfaces. Also included are requirements for GPS integration and testing, and operational requirements that relate to the above interfaces.

This ICD shall be approved and signed by the authorized representatives of GSFC, Swales, and Litton to indicate agreement with the provisions contained herein. The approved document shall then become effective immediately and binding on the participating organizations until a mutually agreed upon revision is released.

Approval of this document by the responsible signatories certifies that

- This ICD establishes the controlled spacecraft-to-GPS interface requirements.
- The GPS and the EO-1 spacecraft will meet the design and fabrication requirements of this ICD.
- The GPS and the EO-1 spacecraft will meet the integration, testing, and operations requirements and constraints specified.

1.2 Applicable Documents

Document No.	Title	Date
SAI-SPEC-158	Verification Plan Specification for the NMP EO-1	
ANSI/ASQC 9001	Quality Management and Quality Assurance Standards Guideline for Selection and Use	8/91
NHB 5300.4(3L)	Requirements for Electrostatic Discharge (ESD) Control	8/93
MIL-STD-1246C	Product Cleanliness Levels and Contamination Control Program	12/94
MIL-STD-810E	Environmental Test Methods Standard	12/95
MIL-STD-462	Measurement of Electromagnetic Interference Characteristics Test Methods Standard	12/95
Loral E101050	GPSAODS and GPSODS Performance Specification	7/97
Loral E101027	GLOBALSTAR GPS Tensor System Proto/Flight Qualification/Acceptance Test Procedure	1/97
Loral E034580	RPU Interface Control Drawing	3/95
Loral E034811	Four-Channel P/SA Interface Control Drawing	3/95
Loral E123167	GPS Antenna Interface Control Drawing	10/96
Loral E123168	GPS Antenna Interface Control Drawing	10/96
Loral E123169	GPS Antenna Interface Control Drawing	10/96
Loral E123170	GPS Antenna Interface Control Drawing	10/96
AM-149-C620(155)	EO-1 System Level Electrical Requirements	6/97

1.3 ICD Revision

Revisions to this ICD shall be proposed using the EO-1 project-level configuration management system.

~~1.4 ICD Requirement Status~~

~~The following notations are used in this ICD to identify parameters and/or requirements that have not yet been finalized:~~

~~TBD: to be determined—Requirements that have not been sufficiently defined at this time.~~

Section 2. Physical Characteristics

The GPS source control drawings (PCU, RPU, P/SA, and GPS antenna) define the system's size, weight, and mounting specifications. The descriptive information that follows is for reference only.

2.1 Power Conditioning Unit

The PCU (Figure 2-1) contains one circuit board, which converts the input voltage provided by the spacecraft bus (28±7 VDC) to that which is required by the RPU (29±3 VDC). The function of the PCU is to isolate, modify, and optimize the spacecraft power, thus providing usable power to the RPU. The optimizing parameters are line/load regulation, efficiency, power dissipation, in-rush current limitation, output ripple voltage, and input voltage range. The dimensions of the PCU are 169 x 133 x 48 mm (6.66 x 5.25 x 1.875 in.), and the weight is 0.97 kg (2.15 lb).

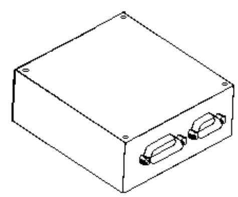

Figure 2-1. EO-1 GPS Power Conditioning Unit

2.2 Receiver Processor Unit

The RPU (Figure 2-2) contains three circuit boards: DC/DC converter board, RF down converter board, and digital board. The DC/DC converter board converts the input voltage to the desired levels needed to power the remaining two boards. The RF down converter board down converts the L_1 C/A code signal (1575.52 MHz) to an intermediate frequency of 4 MHz. A digital signal processing chip and a RISC computer on the digital board perform carrier tracking, code tracking, navigation data recovery, and navigation and attitude calculations. The dimensions of the RPU are 279 x 38 x 178 mm (11 x 1.5 x 7 in.), and the weight is 2.3 kg (5 lb).

2.3 Preamplifier/Splitter Assembly

The P/SA (Figure 2-3) is capable of accepting input signals from four separate antennas. It amplifies these signals by a gain of approximately 45 dB and splits each amplified signal into two signals. The splitting capability allows an antenna signal to be routed to two separate input ports of one or more RPUs. The dimensions of the P/SA are 152 x 51 x 76 mm (6 x 2 x 3 in.), and the weight is 0.5 kg (1 lb).

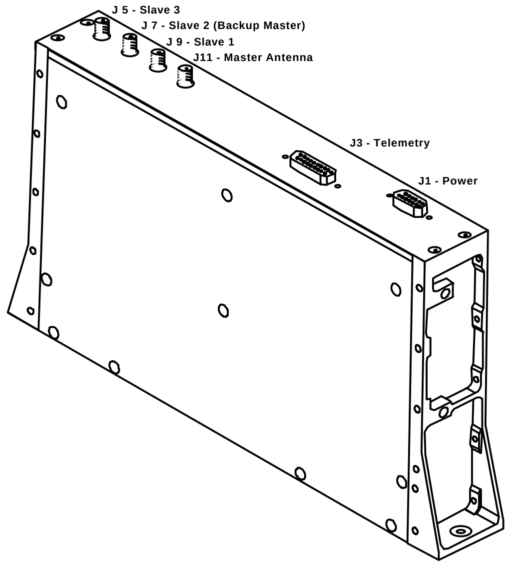

Figure 2-2. EO-1 GPS Receiver Processor Unit

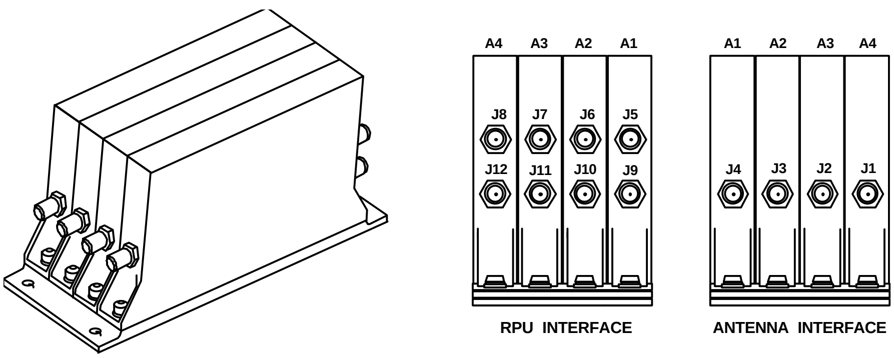

Figure 2-3. EO-1 GPS Preamplifier/Splitter Assembly

2.4 GPS Antenna

Each of the passive antennas (Figure 2-4) is made of a ceramic patch substrate that receives L_1 GPS satellite navigation signals at the center frequency of 1575.42 MHz. The L_1 signal levels at the antennas are in the range of -150 dBW to -161 dBW. The dimensions of the antenna are 76 x 76 x 8 mm (3 x 3 x 0.3 in.), and the weight is 0.14 kg (0.3 lb). The dimensions given exclude the connector on the bottom of the patch antenna. The connector extends approximately 0.4 in. from the offset center of the base of the antenna.

Table 2-1 provides the specifications for the EO-1 GPS antennas.

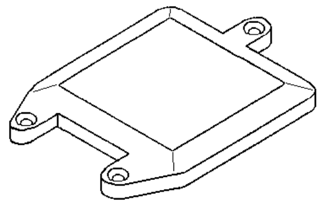

Figure 2-4. EO-1 GPS Antenna

Table 2-1. Specifications for the EO-1 GPS Antennas

Frequency	1573.4 - 1577.4 MHz
Polarization	Right-hand circular
Gain	4.5 dBi
Azimuth coverage	Omnidirectional
Elevation coverage	Hemispherical

2.5 Total Weight

The estimated total weight of the GPS (one PCU, one RPU, one four-channel P/SA, and four GPS antennas) is 4.33 kg (9.54 lb). This weight excludes any brackets, harnessing, or RF cabling.

Section 3. Electrical Characteristics

A diagram showing GPS and spacecraft connections is given in Figure 3-1.

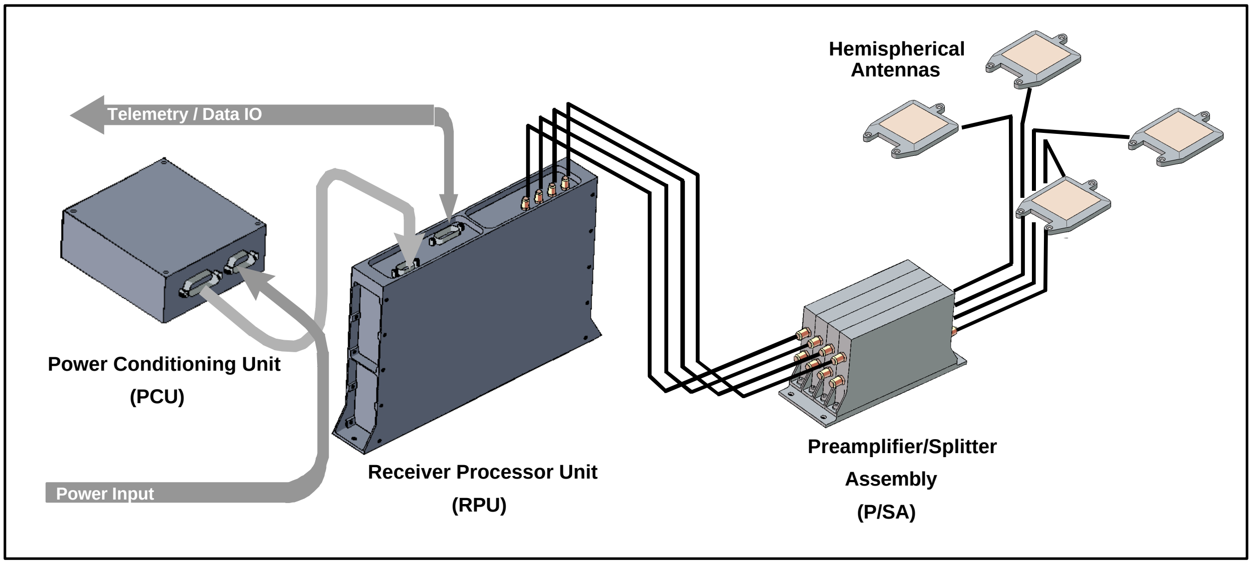

Figure 3-1. EO-1 GPS System

3.1 Power Consumption/Dissipation

3.1.1 Power Conditioning Unit

At the orbital average 10-W output level, the PCU will dissipate less than 4~~2~~ W. At the maximum 16-W output level (at system power-up), the PCU will dissipate less than 6~~3.2~~ W.

3.1.1.1 PCU Line Load Regulation

The PCU shall operate effectively from an input voltage range of 21 VDC to 35 VDC.

3.1.2 Receiver Processor Unit

The power consumption of the RPU is 10 W, orbital average, and 16 W, maximum. Included in this is the 1 W necessary to power the P/SA. The RPU dissipates 9 W, orbital average, and 15 W, maximum.

3.1.3 Preamplifier/Splitter Assembly

The P/SA does not require an external power source because it receives approximately 1 W from the RPU through RF cabling.

3.1.4 GPS Antenna

The GPS antennas are passive devices that do not consume or dissipate any power.

3.1.5 Total Power Consumption

The estimated total power *consumption* of the GPS (one PCU, one RPU, one four-channel P/SA, and four GPS antennas) from the spacecraft bus is 12 W, orbital average, and 19 W, maximum.

3.2 Electrical Interface

The GPS shall meet all electrical interface requirements as stated in the EO-1 System Level Electrical Requirements document [AM-149-C620(155)].

3.2.1 Power Conditioning Unit

The connectors on the PCU are shown in Figure 3-2. Connector J1 is the power input connector, a 9-pin, low-density, subminiature “D” male connector (P/N 311P409~~7~~-1P-B-15). J2 is the power output connector, a 15-pin, low-density, subminiature “D” female connector (P/N 311P409~~7~~-2S-B-15). Tables 3-1 and 3-2 give the J1 and J2 signal definitions, respectively.

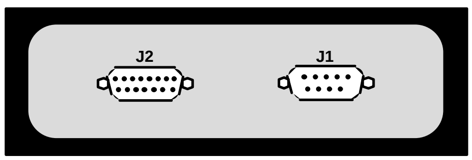

Figure 3-2. PCU Electrical Interface

Table 3-1. PCU Input Connector (J1) Signal Definition

Pin	Signal name	Signal Definition
01	+28 VDC (+/-7 VDC)	Main power input from spacecraft bus
02	+28 VDC (+/-7 VDC)	Main power input from spacecraft bus
03	Spare	
04	Return	Main power return to spacecraft bus
05	Return	Main power return to spacecraft bus
06	+28 VDC (+/-7 VDC)~~Spare~~	Main power input from spacecraft bus
07	Spare	
08	Spare	
09	Return~~Spare~~	Main power return to spacecraft bus

Table 3-2. PCU Output Connector (J2) Signal Definition

Pin	Signal name	Signal Definition
01	(Neg) Temperature	
02	Telemetry	
03	Telemetry return	
04	Return	Main power return from RPU
05	Return	Main power return from RPU
06	Spare	
07	+30 VDC (+/-1 VDC)	Main power output to RPU
08	+30 VDC (+/-1 VDC)	Main power output to RPU
09	(Pos) Temperature	
10	Spare	
11	Spare	
12	Return	Main power return from RPU
13	Spare	
14	Spare	
15	+30 VDC (+/-1 VDC)	Main power output to RPU

3.2.2 Receiver Processor Unit

The connectors on the RPU are shown in Figure 3-3. Connector J1 is the power connector, a 15-pin, high-density, subminiature "D" male connector (Positronics Industries, P/N DD15M4B300S). J3 is the RS-422 data connector, a 26-pin, high-density, subminiature "D" female connector (Positronics Industries, P/N DD26F4B300S). Connectors J5, J7, J9, and J11 are the RF inputs into the RPU; they are female SMA connectors (MA-COM, P/N 2064-5038-94).

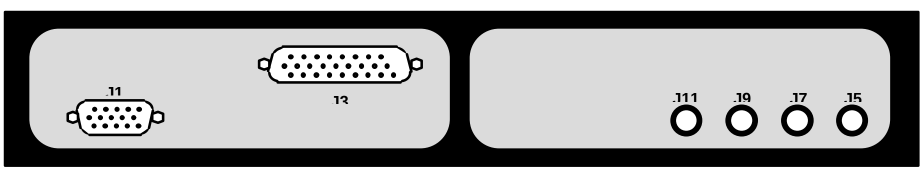

Figure 3-3. RPU Electrical Interface

3.2.2.1 RPU Data Connector

The RPU data connector incorporates a dual (primary and secondary) RS-422 interface that is an asynchronous, bidirectional, standard serial port, which operates at RS-422 differential signal levels but carries an RS-232 serial byte stream. The serial byte stream is sent least-significant-bit first at 19.2 Kbaud, 8 data bits, odd parity, and 1 stop bit. The dual RS-422 design allows interfacing to two separate computers, if desired. The "packetized data" output on both RS-422 outputs are identical. The data port is connected to the EO-1 housekeeping remote services node (RSN), which converts the data to 1773 protocol for communication with the EO-1 onboard computer (Mongoose V).

The RPU also has two (primary and secondary) discrete one-pulse-per-second outputs that are connected directly to the EO-1 housekeeping RSN. The RPU provides precise time to the spacecraft in a "the time at the tone will be" format. Digital time in packetized format is sent to the spacecraft housekeeping RSN through the RS-422 interface followed by the pulse-per-second, UTC-synchronous discrete signal, which is sent directly from the receiver to the housekeeping RSN processor. This message pair is sent to the housekeeping RSN once every second. The housekeeping RSN then calculates the correct UTC for use in the EO-1 onboard computer. The pulse-per-second waveform is a 1-ms wide, 5-V, differential pulse signal that is synchronous with the UTC on its rising edge. The digital time precedes the pulse by 875 ms. The pin and signal definitions of the RS-422 data connector are given in Table 3-3.

Table 3-3. RS-422 Data Connector (J3) Signal Definition

Pin	Signal Name	Signal Definition	Input/Output
01	TXD1 (+)	Transmit data 1 (+)	Output
02	TXD1 (-)	Transmit data 1 (-)	Output
03	Chassis ground		
04	TFC1 (+)	Transmit flow control 1 (+)	Input
05	TFC1 (-)	Transmit flow control 1 (-)	Input
06	RXD1 (+)	Receive data 1 (+)	Input
07	RXD1 (-)	Receive data 1 (-)	Input
08	Chassis ground		
09	RFC1 (+)	Receive flow control 1 (+)	Output
10	RFC1 (-)	Receive flow control 1 (-)	Output
11	TXD2 (+)	Transmit data 2 (+)	Output
12	TXD2 (-)	Transmit data 2 (-)	Output
13	Chassis ground		
14	TFC2 (+)	Transmit flow control 2 (+)	Input
15	TFC2 (-)	Transmit flow control 2 (-)	Input
16	RXD2 (+)	Receive data 2 (+)	Input
17	RXD2 (-)	Receive data 2 (-)	Input
18	Chassis ground		
19	RFC2 (+)	Receive flow control 2 (+)	Output
20	RFC2 (-)	Receive flow control 2 (-)	Output
21	Chassis ground		
22	PPS1 (+)	Pulse per second 1 (+)	Output
23	PPS1 (-)	Pulse per second 1 (-)	Output
24	Chassis ground		
25	PPS2 (+)	Pulse per second 2 (+)	Output
26	PPS2 (-)	Pulse per second 2 (-)	Output

3.2.2.2 RPU Power Connector

The RPU power port (J1) is connected to the GPS PCU. Pins 13, 14, and 15 of this connector are internally connected inside the RPU; therefore all three of these pins may be used for triple redundancy. The pin and signal definitions of the power connector are given in Table 3-4. ON/OFF control of the RPU shall be controlled by the same housekeeping RSN the telemetry connector is harnessed to; therefore, three pins from the power connector (pins 8, 9, and 10) will be harnessed to the housekeeping RSN as shown in Figure 3-4.

Table 3-4. RPU Power Connector (J1) Signal Definition

Pin	Signal name	Signal Definition
01	Spare	
02	Spare	
03	Spare	
04	Pulse return 2	Remote unit #2 control signal return
05	Off—Pulse 2	Power off control from remote unit #2
06	Return	Main power return to PCU
07	On—Pulse 2	Power on control from remote unit #2
08	Pulse return 1	Remote unit #1 control signal return
09	Off—Pulse 1	Power off control from remote unit #1
10	On—Pulse 1	Power on control from remote unit #1
11	Return	Main power return to PCU
12	Return	Main power return to PCU
13	+29 VDC (+/-3 VDC)	Main power input from PCU
14	+29 VDC (+/-3 VDC)	Main power input from PCU
15	+29 VDC (+/-3 VDC)	Main power input from PCU

3.2.3 Preamplifier/Splitter Assembly

The power interface from the RPU to the P/SA is through the RF cabling. Each preamplifier in the assembly is powered separately through its own RF cable. The connectors on the P/SA are shown in Figure 2-3. Connectors J1 through J4 are the input ports that interface to the antennas. Connectors J5 through J12 are the output ports that interface to the RPU. Because this assembly is also a splitter, the signals are split as follows: J4~~1~~ into J5 and J9, J3~~2~~ into J6 and J10, J2~~3~~ into J7 and J11, and J14 into J8 and J12. Connectors J5 through J12 are female SMA connectors (MA-COM, P/N 2064-5038-94).

3.2.4 GPS Antenna

Each antenna has one female SMA connector (MA-COM, P/N 2064-5038-94).

3.2.5 RF Cabling

The RPU, P/SA, and antennas are interconnected with 50-Ohm, SMA-type, male, RF coaxial cables. GSFC will provide these RF cables connecting as indicated in the deliverables section of this ICD. The lengths and connectivity of the RF cables are given in Table 3-5. The tolerances of the cable lengths are ±0.5 in.

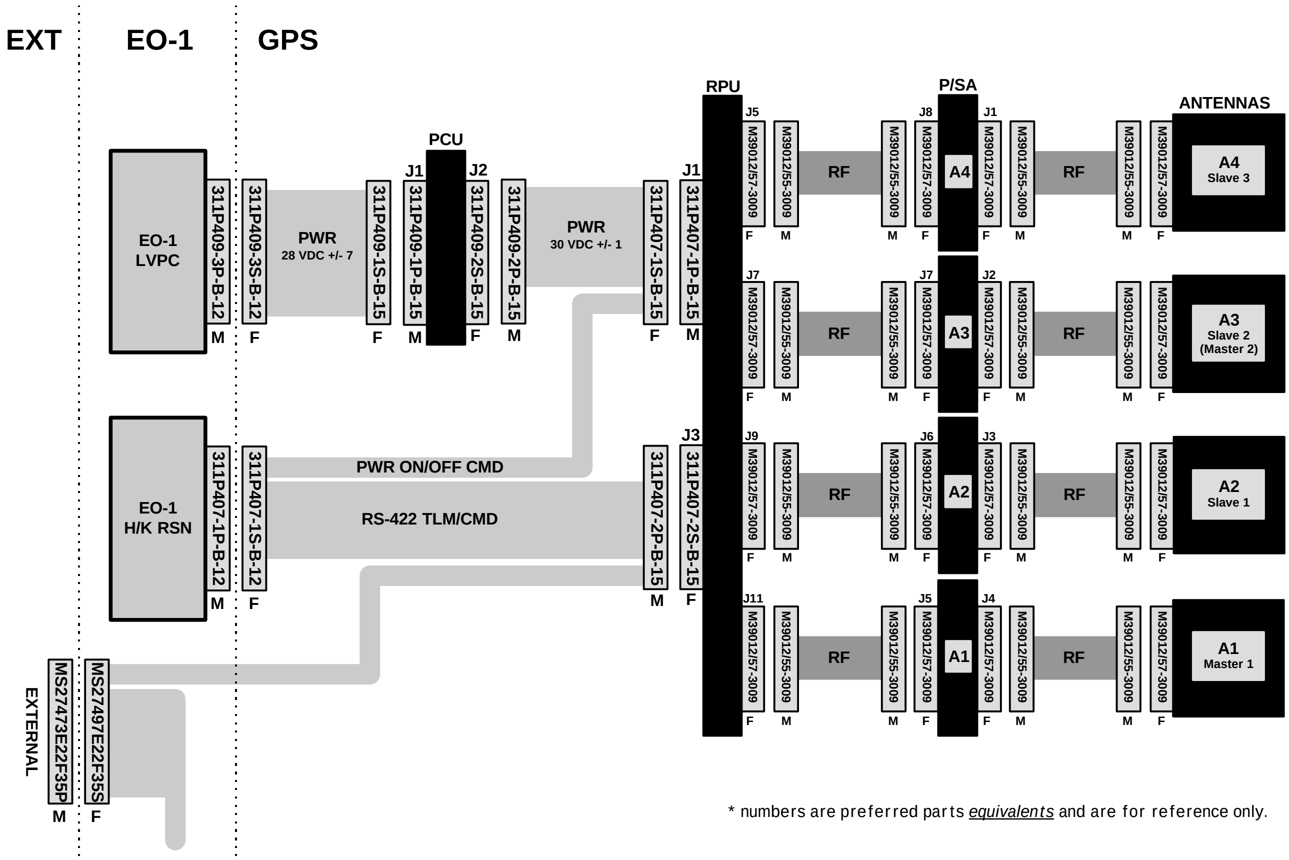

Figure 3-4. GPS Electrical Interface Diagram

Table 3-5. GPS RF Cable Lengths and Connectivity

From	To	Length	Serial No.	Cable Type
Antenna #1	P/SA J4 (A1)	147~~2'-0~~″	1191971~~TBD~~	0.190 Gore
Antenna #2	P/SA J3 (A2)	147″~~12'-0″~~	1191972~~TBD~~	0.190 Gore
Antenna #3	P/SA J2 (A3)~~P/SA J2 (A3)~~	147″~~12'-0″~~	1191973~~TBD~~	0.190 Gore
Antenna #4	P/SA J1 (A4)	147″~~12'-0″~~	1191974~~TBD~~	0.190 Gore
P/SA J5	RPU J11	45~~3'-6~~″	1191965~~TBD~~	0.190 Gore~~RG-142~~
P/SA J6	RPU J9	45″~~3'-6″~~	1191966~~TBD~~	0.190 Gore~~RG-142~~
P/SA J7	RPU J7	45″~~3'-6″~~	1191967~~TBD~~	0.190 Gore~~RG-142~~
P/SA J8	RPU J5	45″~~3'-6″~~	1191968~~TBD~~	0.190 Gore~~RG-142~~

3.2.6 Wire Harness

The EO-1 Project will supply all wire harnessing (and connections) between the EO-1 spacecraft and the GPS subassemblies.

3.3 Operating Duty Cycle

The GPS shall be turned on after orbital injection and remain on, operating continuously at a 100 percent duty cycle throughout the 1-year design life of the EO-1 spacecraft.

3.4 Electrical Isolation

The GPS shall maintain isolation greater than 1 megaohm~~MW~~ between the spacecraft primary power circuits and the RS-422 data circuits.

Section 4. Mechanical Interface

4.1 Centers of Gravity

The estimations of the locations of the centers of gravity for the PCU, RPU, P/SA, and antennas are given in Table 4-1.

Table 4-1. Estimated Locations of the Centers of Gravity for GPS Subassemblies

	PCU	RPU	P/SA	Antennas
CM_x	81.28 mm	23.9 mm	25.40 mm	35.56 mm
CM_y	67.44 mm	133.0 mm	69.09 mm	35.56 mm
CM_z	18.92 mm	82.4 mm	31.75 mm	15.24 mm

4.2 Mounting Access and Alignment

4.2.1 Power Conditioning Unit

The PCU will be mounted in the EO-1 bay 6, as is shown in Figure 4-1.

4.2.2 Receiver Processor Unit

The RPU was originally designed to be flown as a redundant pair, bolted together. For the EO-1 spacecraft, a single RPU will be flown, requiring a bracket support as shown in Figure 4-2. The RPU (in its bracket) will in turn be mounted in the EO-1 bay 6, as is shown in Figure 4-1.

4.2.3 Preamplifier/Splitter Assembly

The P/SA will be mounted in the EO-1 bay 6, as is shown in Figure 4-1.

4.2.4 GPS Antennas

Four antennas shall be mounted on mounting brackets as shown in Figure 4-3. The mounting brackets for the antennas will accommodate the electrical and thermal needs of the antennas. Four such brackets shall be mounted on the zenith pointing deck of the EO-1 spacecraft according to the arrangement shown in Figure 4-4.

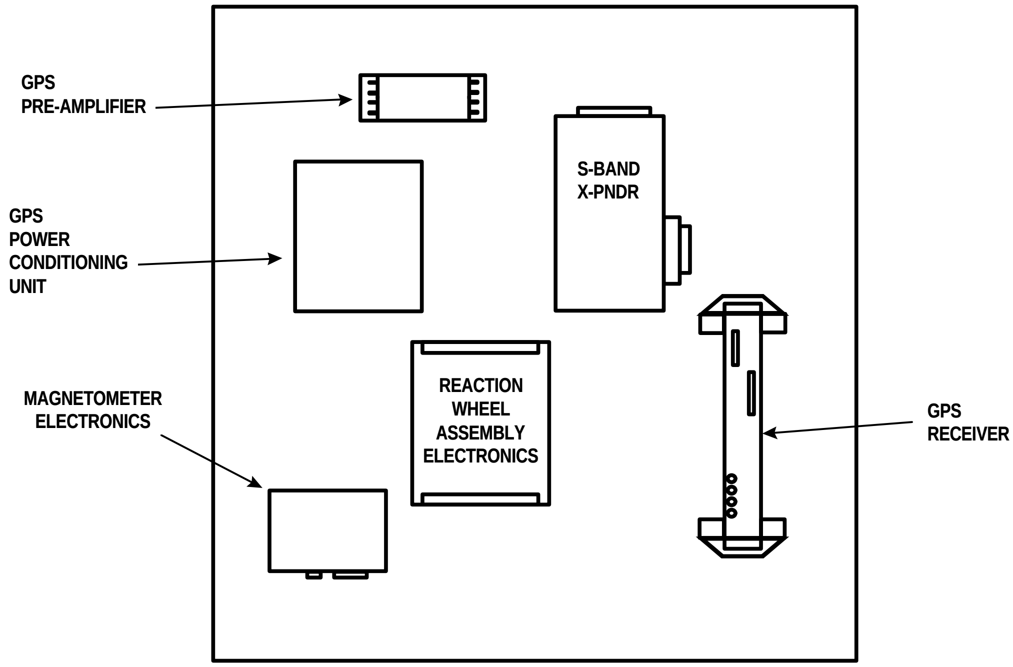

Figure 4-1. EO-1 Bay 6 Layout

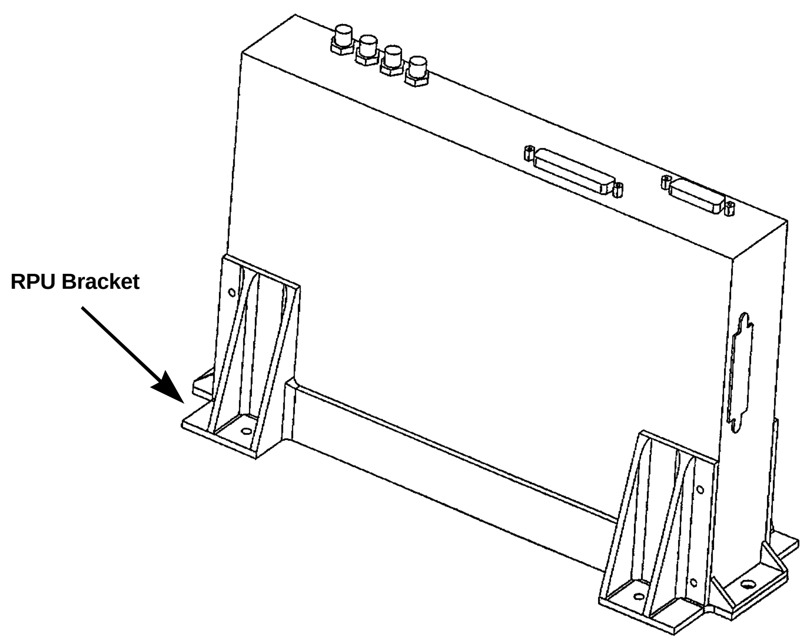

Figure 4-2. Single String RPU Bracket

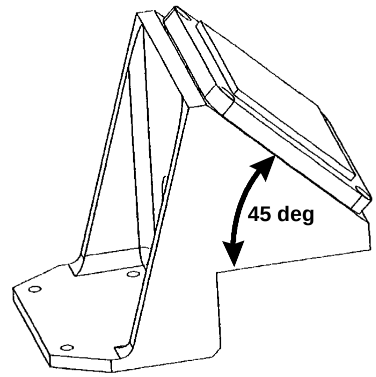

Figure 4-3. GPS Antenna Mounting Bracket

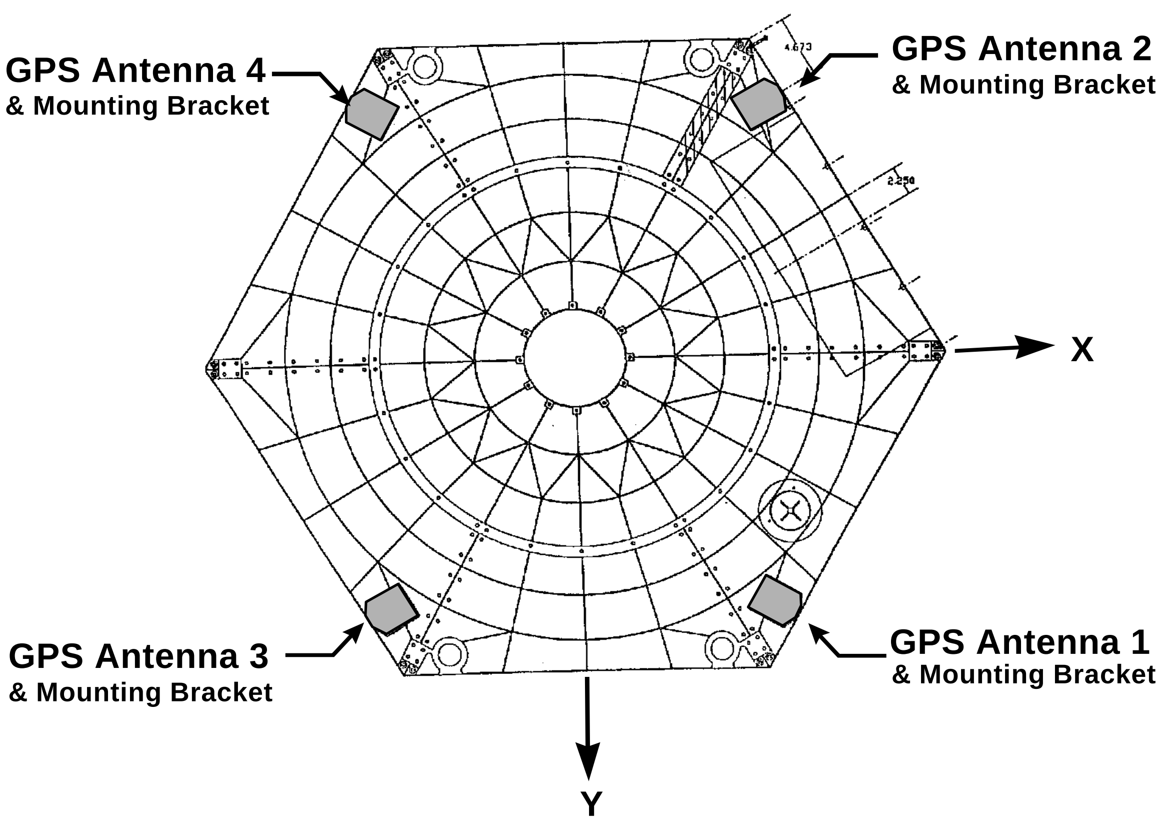

Figure 4-4. GPS Antenna Mounting on EO-1 Zenith Pointing Deck

Section 5. Software Description

All data interface characteristics including all data packet definitions, formats, and timing are outlined in explicit detail in Loral-controlled document E101050, *GPS Attitude and Orbit Determination System and GPS Orbit Determination System (GPSAODS and GPSODS) Performance Specification*.

Section 6. Operational Requirements

The following sections define the necessary steps for the successful operation of the GPS. Before proceeding, a clear definition of the terms *command* and *telemetry* is in order. Initialization commands are packets that are sent to the Tensor to configure it for flight operations. These commands are sent to the Tensor only once following a power-on sequence. If the power to the Tensor is cycled, then the initialization commands to the Tensor must be sent again.

6.1 Power-On Sequence

The following steps shall be followed to successfully power-on the GPS:

1. Apply 28 ± 7 VDC spacecraft bus voltage to the PCU.
2. Wait 10 seconds.
3. Apply 26 ± 4 VDC power-on pulse to RPU relay.
4. Wait 20 seconds.
5. After the power-on pulse ~~When power is applied~~ to the RPU, it performs a self-test for approximately the first 20 seconds, in which the RPU enters into a "sleep" mode. In this mode, the RPU will not transmit any telemetry nor will it store or process any commands. Once 20 seconds have elapsed, the RPU autonomously switches into "nominal" mode, enabling telemetry output and the processing of commands. The following steps can now be performed.
6. Set RPU configuration for EO-1 mission via packet 35 & EO [H~~h~~ex].
7. Warm start: Transmit valid almanac to RPU via packet 38 [Hex]~~XX~~ (skip if cold start).
8. Warm start: Transmit valid spacecraft ephemeris to RPU via packet E7 [Hex]~~XX~~ (skip if cold start).
9. Warm start: Transmit valid current time to RPU via packet 2E [Hex]~~XX~~ (skip if cold start).
10. Wait for a valid position fix (for warm start, approximately 5 minutes; for cold start, approximately 45 minutes).
11. Immediately after the Tensor enters into "nominal" mode, it begins to output the default position, velocity, and time packets (the data values of these packets are zero). From a "cold start", the Tensor requires 30 minutes (maximum) to obtain a valid position fix. A health status flag indicates when valid fixes are achieved. A cold start is defined as having no knowledge of current position, time, and GPS almanac information. The time to achieve valid fixes can be reduced to under 3 minutes by providing the Tensor with an initial solution for position and time and a valid GPS satellite almanac. The table below lists the initialization command parameters, sent from the ground through the spacecraft onboard computer to the Tensor, to achieve such a "warm start".

6.2 Power-Off Sequence

To power-off the GPS,

1. Apply 26 ± 4 VDC power-off pulse to RPU relay. No further action is required.

6.3 Commands

Commands to the RPU will be sent from the spacecraft onboard computer.

6.4 Telemetry

The data throughput scheme for the GPS is shown in Figure 6-1. For a detailed description of the data packet definitions and formats, see the Loral-controlled document E101050, *GPS Attitude and Orbit Determination System and GPS Orbit Determination System (GPSAODS and GPSODS) Performance Specification*. GPS telemetry consists of the following:

- To ACS via Buffer A:
  - Pulse-per-second
  - Packet 5E   Digital GPS Time
  - Packet A1   Position, Velocity, and Health
  - Packet D1   Filtered Position, Velocity
  - Packet 41   UTC Offset
- To ground via Buffer B and polling software:
  - Any and all packets as requested via the polling software

6.5 Performance

6.5.1 Position Accuracy

SPS solutions (point solutions) position specification in “sigma terms” is 450 m (3σ), RSS. This number is when Selective Availability is enabled.

6.5.2 Velocity Accuracy

SPS solutions (point solutions) position specification in “sigma terms” is 1 m/s (3σ), RSS. This number is when Selective Availability is enabled.

6.5.3 Timing Accuracy

Several “timing specs” exist. The timestamps (or timetags) associated with the navigation and attitude fixes (and other packets that contain time-of-fix) are accurate to 1 ms (3σ) of true time (true time can be UTC or GPS). The rising edge of the pulse-per-second discrete pulse train

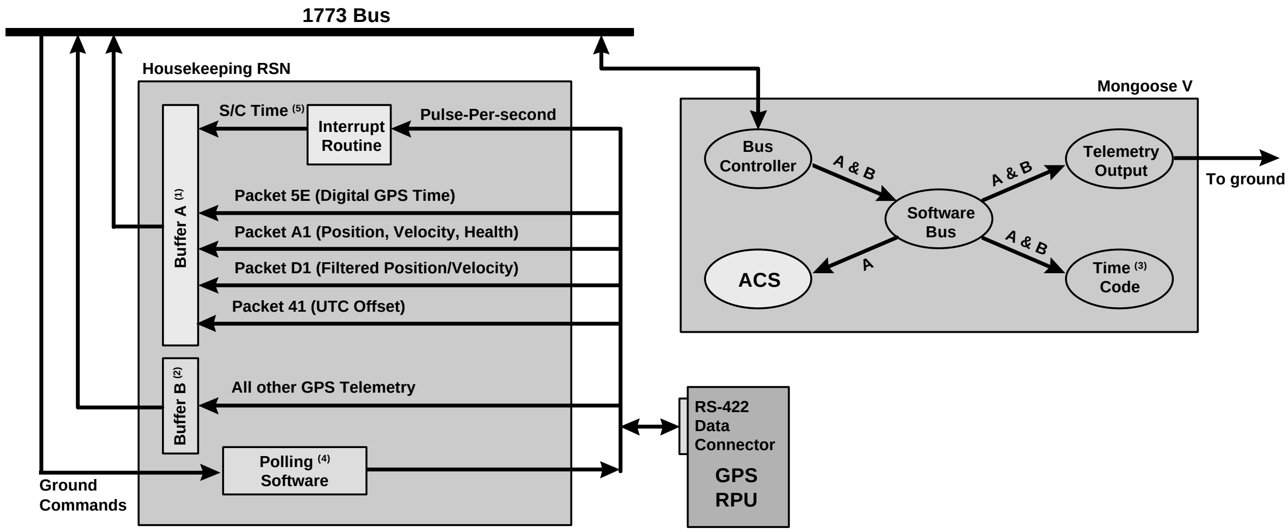

Figure 6-1. GPS to EO-1 Spacecraft Data Throughput

(which is a differential output) is accurate to within 1 μsec (3σ) of every GPS second. However, this 1-μsec accuracy is the "time at the next pulse" message (Loral calls this the digital time) coming from the receiver is only accurate to 1 ms (3σ). If the "digital time" is employed in association with the pulse train, the accuracy will be 1 ms (3σ).

6.5.4 Coordinate Frame

Tensor packet A1 gives the single-precision position and velocity in rectangular coordinates at an autonomous ouput rate of 1 Hz. In packet 35 hex (I/O options), Byte #0, Bit 7, one can set the coordinate frame to ECI. In the same packet, Byte #0, Bit 3, can be used to set the ECI coordinate frame time reference to J2000 true-of date, which is, in fact, the default output state of the Tensor.

6.5.5 Output Update Interval

The Tensor design reflects a 1-Hz computation and output rate for all navigation data.

6.5.6 Number of Antennas

The Tensor has four antenna input ports, labeled Antenna Port 1, Antenna Port 2, Antenna Port 3, and Antenna Port 4. By default (after Tensor power-up), Antenna Port 1 is considered 'master' for navigation. This is hard-coded into the receiver and cannot be changed. If for some reason the path of Antenna Port 1 (path is from the antenna, through the preamplifier, and finally to the receiver) is 'bad' and not working, the Tensor will automatically switch to Antenna Port 3 as master for navigation. Again, this backup master port for navigation is hard-coded into the receiver and cannot be changed. There is, however, a packet 63 hex that the user can send to the Tensor to force the receiver to use any of the four antenna ports as master for navigation.

Section 7. Deliverables to the EO-1 Project

The following items will be delivered to the EO-1 Project.

7.1 Hardware

The following items will be delivered to the EO-1 Project by July 15, 1998, for integration onto the EO-1 spacecraft:

- One PCU
- One RPU with flight software installed
- One four-channel P/SA
- Four RF terminators for unused P/SA outputs
- Four GPS antennas
- Four 147~~12′ 0~~″ RF cables connecting the antennas to the P/SA
- Four 45~~3′ 6~~″ RF cables connecting the P/SA to the RPU
- GSE
- Roof antenna
- Cable and amplifiers
- Two hat couplers
- Two GPS simulators

7.2 Documentation

With delivery of the GPS hardware to the EO-1 Project, GSFC will submit an End Item Data Package including, but not limited to, a certificate of compliance, test results/reports, and test procedures.

7.2.1 Certificate of Compliance

A Certificate of Compliance will be submitted with the GPS hardware indicating compliance to each of the following topics:

- Safety
- Physical interface
  - Mechanical
  - Electrical

- Environmental interfaces
  - Structural
  - Thermal
  - Mass properties
  - Temperature
- Functional interface
  - Power
  - Command
  - Telemetry

7.2.2 Test Results/Reports

Test results and/or reports on the following tests must be submitted:

- Vibration test
- Thermal vacuum test
- Performance test

7.2.3 Test Procedures

TBD

7.3 Checkout and Operation Constraints for Spacecraft Integration

GSFC will perform a functional test of the GPS at the GSFC simulation facility prior to officially releasing the hardware to the EO-1 Project. GSFC will support spacecraft-level integration testing of the GPS.

7.4 Contamination and Handling Procedures

The GPS will comply with the contamination control and handling as given in the EO-1 Contamination Control Plan. The GPS has no special contamination requirements.

Section 8. EO-1 Spacecraft Specifics

8.1 Electrical Power

The spacecraft provides switched, unregulated, fused power of 28 to 35 VDC to the PCU. As mentioned previously, the PCU in turn provides power to the RPU and to the P/SA via the RF cabling.

~~8.1.1 Fuses and Protection~~

~~The spacecraft current to the RPU will be limited through a 2-A fuse.~~

8.2 Thermal Control

8.2.1 Power Conditioning Unit

The spacecraft will maintain the temperature of the PCU between 0°C and +40°C when operating. The non-operating survival temperature limits for the PCU will be -10°C to +50°C.

8.2.2 Receiver Processor Unit

The spacecraft will maintain the temperature of the RPU between 0°C and +40°C when operating. The non-operating survival temperature limits for the RPU will be -10°C to +50°C.

8.2.3 Preamplifier/Splitter Assembly

The spacecraft will maintain the temperature of the P/SA between 0°C and +40°C when operating. The non-operating survival temperature limits for the P/SA will be -10°C to +50°C.

8.2.4 GPS Antennas

The spacecraft will maintain the temperature of the GPS antennas between 0°C and +40°C when operating. The non-operating survival temperature limits for the GPS antennas will be -10°C to +50°C.

Abbreviations and Acronyms

°C	degree Celsius
µsec	microsecond
A	ampere
ACS	Attitude Control System
dB	decibel
dBi	decibel isotropic
dBW	
DC	direct current
ECI	Earth-centered inertial
EO-1	Earth Orbiter 1
GPS	Global Positioning System
GSE	
GSFC	Goddard Space Flight Center
Hz	hertz
ICD	interface control document
in.	inch
I/O	input/output
kg	kilogram
lb	pound
LVPC	low voltage power supply
m	meter
MHz	megahertz
mm	millimeter
m/s	meter per second
ms	millisecond
NASA	National Aeronautics and Space Administration
NMP	New Millennium Program
PCU	Power Conditioning Unit

P/N	part number
P/SA	Preamplifier/Splitter Assembly
PPS	pulse per second
RF	radio frequency
RFC	receive flow control
RISC	
RPU	Receiver Processor Unit
RSN	remote services node
RXD	receive data
SCD	source control drawing
SMA	
SPS	Standard Positioning Service
SS/L	Space Systems/Loral
TFC	transmit flow control
TXD	transmit data
UTC	universal time code
V	volt
VDC	volt direct current
W	watt